Bonded Joints in Military Aircraft

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Bonded Joints in Military aircraft

- Successfully used since mid 80’s
- Major composite structure for production aircraft
- UK Examples include.....
Future Military Aircraft - Challenges

• Previous military aircraft projects
  • Design phase several years
  • Typically 1000+ aircraft
  • Large projects, long development, high cost

• Future aircraft programmes
  • Small batch numbers
  • Multiple customers / configurations
  • Rapid design process (months not years!)
  • Lower cost manufacturing methods
  • BUT still same level airworthiness

• Option - Bonded structure
  • Problems....
Low Cost Manufacturing Approach

Possible manufacturing solutions include:
  • Out of autoclave processing
  • Different material systems
  • Low cost tooling

• Bonded rather than bolted structures
• Applications include eg
  • Skin to substructure bonding
  • Spar to rib cleating
Composite assembly tolerance control issues

- Eg Bonded J spar configuration

All composite thicknesses typically +/- 6%

Controller aerodynamic girth

- Use precured skins for tolerance control
- Works well
- Expensive tooling
- Inflexible
- Not appropriate for small batches

Film adhesive
Constant thickness

PRE-CURED CFC SKINS

UN-CURED 'Z' & 'C' SPAR ELEMENTS

'CLEAVAGE' FILLED WITH UN-CURED CFC WEDGE

UN-CURED 'Z' & 'C' SPAR ELEMENTS

'FILM' ADHESIVE

CONFORMABLE TOOLING SHOWN THUS:
Assembly advantages of paste adhesive

**Advantages**
- New paste adhesives – similar strength to film adhesives
- Gap filling capability
- Dimensional control with cheap tooling
- Appropriate small batch manufacture

**Problems/ Disadvantages**...
• Problems/ Disadvantages......
  • Pre- cured parts
  • Surface preparation / cleaning
  • Potential contamination
  • Determining / ensuring integrity of bond
Approach for improvement......

• Addressing whole process

• Before Bonding
  • Advanced cleaning methods
  • Advanced inspection methods skins after cleaning

• After bonding:
  • Advanced NDT to identify defects ?
  • SHM techniques on bondline ?
  • Advanced analysis techniques – bond strength defect analysis

Potential techniques under consideration
Surface Preparation and Cleaning

- Manual cleaning operation
  - High skill activity ....
  - Could possibly miss the op out altogether...
- Aim – method to take man out of the loop
  - Options include
    - eg plasma cleaning being investigated
    - But sometimes:
      - not remove all contaminants
      - Alter contaminant surface without removing
Traditionally surface wetting

Aim – Automate, take man out of the process.

Advanced inspection methods

- eg FTIR
  - Issues detecting modified contaminant

FTIR spectrum,
- 3 specimens silicone contamination
- one control
Adhesive Bonded Joint Problems

- Bigger issue with paste than film adhesives
- Particularly:
  - More Porosity / voids - limits ability to NDT
  - Surface issues – disbands / kissing (zero volume bonds) / low strength adhesion
  - Poor mixing
  - Thicker bondlines can lead to more cracking
• Currently:
  • HAVE to proof load the structure
  • “We must find an NDT technique that gets us away from this position”
  • How does SHM fit in with this?
Summary

- Future military aircraft
  - Small batch production
  - Short timescales
  - Low cost
  - Same level airworthiness

- New paste adhesives:
  - Low cost manufacturing

- Need to demonstrate bond integrity
  - Currently MUST proof load
  - Need NDT technique to move from this position
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